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ABSTRACT

The mathematics teacher has the major responsibility of assisting pupils to learn in ongoing lessons and units of study. Motivating pupils to achieve optimally is a concern of conscientious teachers. This paper discusses the major educational theories emphasizing motivation and presents guidelines for teaching mathematics. (ASK)

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MOTIVATING PUPILS TO LEARN IN MATHEMATICS

Marlow Ediger

The mathematics teacher has a major responsibility in assisting pupils to learn in ongoing lessons and units of study. Thus, motivating pupils to achieve optimally is a concern of conscientious teachers. When observing pupils in a classroom, there are highly motivated pupils who work hard on the task at hand and they do well in attaining vital goals of instruction. Others are less motivated and their attention may be divided between the lesson at hand and distractions in the classroom. And yet, these pupils may complete assignments on time with minimal quality. A few pupils need much guidance to complete assignments and fail to achieve as well as desired by the mathematics teacher. Each pupil is important and no one should fall through the slats in mathematics. Mathematics is one of the three R's (reading, writing, and arithmetic). Knowledge, skills, and attitudes as objectives to achieve are vital for each pupil. Learners presently need to attain as optimally as possible so that at the work place as adults, there is a better chance to be successful and receive adequate remuneration to live a decent life style. Thus, pupils need to be motivated to do well in the mathematics curriculum.

Behaviorism and the Mathematics Curriculum

E. L. Thorndike (1874-1949) established foundational ideas for behaviorism as a psychology of learning during the early years of the 1900s. His stimulus/response school of thought in terms of how animals learn was translated to the teaching of pupils in the school setting. Thorndike did much experimenting with cats going through a maze. The cat that followed the maze successfully was rewarded with a fish at the end of the maze. The Law of Effect was then developed by Thorndike in that the cat went through the maze more rapidly, with repeated attempts, than formerly due to the reward at the end of the maze. The effect was

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the available fish to eat. Thorndike also developed the Law of Frequency (the more often the cat went through the maze, the more likely the animal would learn quickly how to complete the task with minimal errors), the Law of Recency (the more recent the event, the more likely the animal would remember the task --Recency instead of something having happened some time ago). The latter two laws have been discarded since there are other factors that enter in , other than something being learned frequently and recently. The Law of Effect has remained important by behaviorists, in numerous situations.

B. F. Skinner (1902-1986) did many research studies and came up with the concept of operant conditioning. With operant conditioning, Skinner placed major emphasis in learning upon the response in S-R theory of learning as compared to the stimulus. Thus, for example, the mathematics teacher may be assisting pupils with learning what 5+4 is in a meaningful and interesting procedure of instruction. If the pupil responds with "nine" as the answer, he/she is rewarded. The emphasis here is placed upon the response in operant condition, not the stimulus. the teacher may say. "That is good," when a learner responds correctly. The response then is further reinforced in operant conditioning through verbal praise. With reinforcement theory , pupils learn more quickly and retain learnings longer, according to B. F. Skinner. With operant conditioning, the following steps are salient for the teacher to follow:

1. specifying what pupils are to learn prior to instruction.
2. writing these ends in measurable terms, with great specificity.
3. teaching each lesson in very small incremental steps.
4. learning by pupils occurs as each small item of content is acquired sequentially.
5. providing feedback continuously to pupils on how well each is doing with verbal praise and with the correct answer.
6. reinforcing positive pupil behavior in terms of subject matter learned as well as study skills acquired (Ediger, 1997).

Schedules of reinforcement may be in the offing as advocated by

behaviorists. The schedule of rewards may be based on a ratio basis such as a verbal reward for every three correct responses given by a pupil. Time may also be used as a basis for rewarding pupils with a verbal reward. Thus, for a pupil with poor study habits in mathematics, if he/she completes three basic addition facts correctly in two minutes, praise is given here. The schedules of reinforcement can be altered depending upon how frequently the pupil needs a reward to continue achieving more optimally.

Presently, behaviorism emphasizes the writing of predetermined , precise objectives for pupils to achieve in mathematics. These specific objectives are written so that teachers and pupils know exactly what pupils are to learn. Objectives then are available to teachers prior to instruction. The teacher may announce what pupils are to achieve within a lesson. This provides security to the learners in terms of knowing what the outcomes of teaching are to be. The following are examples of behaviorally stated objectives for the pupil to achieve within a lesson:

1. The pupil will add correctly nine out of ten addition basic number pairs, each containing single digit addends.
2. The pupil will check his/her addition by using the commutative property of addition.

Adding correctly nine out of ten in the above objective #1 is a minimum level of acceptance. Ten out of ten is the ideal! There are teachers who provide inexpensive rewards if pupils achieve the desired goal in the stated objective. Pupils should know ahead of time in instruction what the physical reward will be so that maximum effort is put forth to achieve and grow in mathematics.

Humanism in the Mathematics Curriculum

Somewhat toward the opposite end of the continuum, humanists advocate their approaches in having pupils achieve more optimally.

Maslow"s hierarchy of needs is fundamental to understand in order to attach meaning to humanism as a psychology of learning. Abraham Maslow (1908-1970) developed a motivation theory based on needs of individuals. The first need stressed meeting physiological needs of pupils such as adequate nutrition, clothing, and shelter provisions. Free breakfasts and lunches in school help, but there are too many other meals that poor children may not be getting. I have often recommended that there should be free suppers for poor children, along with an after school program of education for all pupils. Second, Maslow advocated safety needs of pupils be met. Child abuse and loaded pistols along with other arms brought to school by pupils will not help the situation. Neither does bullying by pupils of other children help to make for a safe school environment. Third, the need for belonging needs to be met. Here, the teacher needs to accept and care for each child. The teacher also needs to guide pupils to accept each other in school and in committee work. Adequate time should be spent by the teacher in helping pupils feel as if they belong in an accepted group. Fourth esteem needs of pupils must be met. Here, the teacher should recognize pupils for accomplishments in class and in outside class/school endeavors. Individuals desire to be recognized for something that is done well. No one desires to be ignored in class. Fifth, the need for self actualization is important. The pupil then becomes the kind of person he/she wishes to become. Sixth, the pupil has a need to understand and know. This stage of needs then stresses, among other things, pupils achieving vital mathematics objectives. Maslow in his well developed hierarchy of needs pinpoints how other needs, than to know and understand are also important and they definitely are. I recommend that the need to know and understand be integrated with the first five needs. A quality mathematics curriculum then needs to be in the offing continuously with its knowledge, skills, and attitudinal objectives. I agree strongly that pupils need to have physiological needs, safety needs, belonging needs, and esteem needs met so that more optimal achievement in mathematics is possible.

How can pupils learn if they are hungry, lack safety, feel as if they do not belong in the classroom, and lack esteem?

Humanism advocates an open ended mathematics curriculum. The following tenets of humanism are important to understand:

1. pupil/teacher planning of the mathematics curriculum. Thus, there needs to be input from the pupil in terms of what is taught in the mathematics curriculum. With a learning centers approach, the pupil may sequentially select from the diverse tasks what to learn and what to omit, but still be profitably occupied continuously. As much as possible, there should be pupil directed learning. Pupils should have a voice in goal determination in the mathematics curriculum. As a university supervisor of student teachers, I have noticed a contract system at work in mathematics. Here, the pupil with teacher guidance establishes a contract of what specifically the learner is to complete in mathematics with a due date thereon. The pupil and the teacher both sign the contract. The teacher is there to assist and help the pupil in contract establishment. In all of the work completed and the inherent processes, pupils should be involved in evaluation. The learner is not to be left out of developing the mathematics curriculum. The attitudinal or affective dimension is very important to a humanist. With much pupil input into the mathematics curriculum, humanists believe attitudes improve. A contract may look like the following:

I agree to complete the following in mathematics

1. do five activities at the enrichment center.
2. do ten tasks at the learning centers.
3. read and report on two library books on mathematics.
4. view two videotapes on mathematics and write summary statements for each.
5. work in a committee to complete collaboratively pages ten and

eleven from the basal.

Signed by the pupil Signed by the teacher

due date

The above contract indicates that the learner is quite subject centered in achievement, especially when looking at the basal text completions being a part of the contract. A pupil who likes an activity centered curriculum may wish to do more construction, visual arts, demonstrations, dramatic activities, and projects as they relate to the ongoing unit of study (Ediger, 1991).

Carl Rogers (1902-1987) was also a leading advocate of humanism, as a psychology of learning, to be emphasized in the classroom. Rogers believed pupils to be naturally curious and thus a child centered mathematics curriculum was needed. Pupils then liked to explore the environment and satisfy their academic needs. The teacher needs to assist pupils to satisfy their curiosity for learning.

Rogers believed that change in society is rather rapid and what the schools stress may soon become outdated. Therefore, pupils need to accept the concept of change and become lifelike learners. Pupils should be able to try out their own ideas without fear of failure or ridicule. The learning environment must therefore be free from threat and criticism.

How to learn and how to become a lifelike learner are very important to humanists, such as Carl Rogers. Self directed learning as an ideal to stress in the classroom and choosing what to learn is highly motivating to pupils. Learner motivation increases with pupils being involved in the making of choices. Self reliance and independence are two concepts strongly advocated by Rogers and they result from self directed learning. The implications here for mathematics teachers,

pertaining to humanism in the classroom, are the following:

1. provide as many opportunities as possible for pupils to select and pursue their very own individual interests. I would like to suggest using, among other approaches, a learning centers philosophy of teaching whereby a learner sequences his own achievement by choosing sequential tasks in mathematics to pursue at the diverse centers.

2. guide pupils to become responsible individuals in doing work in the mathematics curriculum. The teacher may set up several enrichment stations which contain learning activities that go beyond those of the tasks at the diverse learning centers. After completion of regular lessons and assignments, the pupil may then go the enrichment center to learn in depth what was stressed at the leaning centers.

3. encourage life long learning by having the pupil choose a library book on mathematics that is interesting and contains meaning for the involved learner. These library books should be on the individual's reading and understanding level (Rogers, 1983),

Behaviorism and Cognitive Psychology in Mathematics

Robert Gagne' (1985) is a leading psychologist today who advocates both tenets of behaviorism and cognitive psychology. He has been very strong in emphasizing that pupils experience quality sequence in learning. Thus, mathematics teachers are to arrange the objectives of instruction on a continuum from the easiest to the more complex. Careful planning is necessary to do this. The teacher needs to have an excellent knowledge of subject matter to use Gagne's hierarchy of objectives approach in teaching and learning. The eight levels of learning are signal learning, stimulus-response, chaining, verbal association learning, multiple discrimination, concept learning, rule learning, and problem solving.

Gagne's lowest level of objectives for pupils to achieve emphasize signal learning. Signal learning is much like Ivan Pavlov's experiments

in The Soviet Union in 1927, among other years. Here, Pavlov experimented with dogs and their salivation. A dog salivated with the sight of meat and its accompanying odor. Pavlov experimented with pairing the sound of a bell with the sight of the meat. The dog still salivated and continued to do so with the sound of the bell only. Gradually, the salivation lessened and went away completely. This is classical conditioning. The next level is stimulus-response learning whereby, for example, upon seeing 5+4 on a flash card (the stimulus) a pupil responds immediately with nine as the answer. Five plus four is associated with nine (the response). Stimulus-response learning has many uses in teaching, especially with items that need to be committed to memory. Ultimately, after meaning and use have been made of the basic addition, subtraction, multiplication, and division number pairs, they should be committed to memory by pupils so that rapid recall is there when needed. Chaining stresses the pupil doing a series of tasks in proper order whereby psychomotor learnings are involved. In the making of model geometry figures, there is a better and a worse way of making squares, rectangles, circles, semicircles, triangles, and trapezoids. A skillful learner will soon find, when ready, improved ways of making things and in this case model geometrical figures. Chaining is involved in the physical activity. Verbal association learning emphasizes pupils being able to explain sequentially, for example, a new process in arithmetic. Thus in long division, the pupil with a series of meaningful statements explains how 45,637 divided by 84 is done. The explanations involve verbal language and need to follow a definite order so that the listener is clear on the involved steps. Multiple discriminations involve separating the needed from the unneeded in mathematics. When adding, subtracting, multiplying, and dividing, the pupil needs to separate what is necessary from what is incorrect. In doing word problems, there is essential needed information that the problem asks for. The rest needs to be discarded. Multiple discrimination involves critical thinking in separating the relevant from the irrelevant. Level six is concept development of pupils, according to

Gagne'. Pupils need to learn vital concepts. Concepts are represented by single words or phrases. The following, as examples, are concepts: circumference, area, radius, pi, and diameter. Inside of each concept are numerous facts. Thus in the concept of circumference of a circle, the pupil needs to know and understand diameter and pi together with the operation of multiplication. The seventh level of Gagne's model is rule learning. Rules stress pupils developing generalizations. Generalizations are broad, meaningful sentences that relate concepts. For example, The formula for determining the area of a cylinder is radius squared times pi times height. There are several relevant concepts inside this generalization, such as cylinder, radius, squared, pi, times, and height. The last and eighth step of developing an instructional sequence is problem solving. Here, lifelike and word problems, based on the readiness level of the pupil may be used.

A major advantage in using Gagne's hierarchy of objectives psychology is that the mathematics teacher is attempting to develop quality sequence for pupil learning. Thus, if a pupil cannot solve the problem, he/she can go back to earlier levels in the hierarchy such as a learner not understanding and knowing the involved generalization. If the pupil does not know and understand the generalization, he/she may be deficient in the related concepts therein. If the mathematical concepts are not understood, perhaps the pupil is not able to distinguish in multiple discriminations the relevant from the irrelevant in information dealing with the inherent concepts being studied in mathematics.

Guidelines for Teaching Mathematics

I have asked many student teachers and cooperating teachers whom I have supervised in the public schools about what they perceive to be major problems in teaching pupils. The student teachers and cooperating teachers have generally indicated the following:

1. securing attention of pupils in learning mathematics. When

teaching a set of twenty- five pupils in large group instruction, the mathematics teacher needs to use a teaching strategy with diverse kinds of materials to obtain the interests of learners. I observed a classroom whereby the teachers were attempting to have pupils develop a concept of a set of ten. Each pupil was given ten sticks to use as counters. Pupils started to click the sticks so that nothing was achieved in terms of learning about a set of ten. These pupils seemingly were not trying to distract others, but they found it interesting to make these clicking sounds individually. I suggested that the student teacher and the cooperating teacher use a set of large sticks that pupils could see from their desks and then to use discovery methods of learning about what a set of ten is. This avoided the clicking sounds and did help pupils to focus upon the set portrayed by the teacher.

2. having pupils understand what is taught. To understand a set of ten, pupils need to see different materials being used. These materials may include crayons, pencils, chalk, seeds, and paper clips, among other materials. It is important for pupils to perceive that the concept of ten is applicable to all of these materials when saying how many are in a set. Patience is a very important trait of teachers. Pupils learn at different rates of speed and at diverse levels of understanding. If pupils do not learn with one teaching strategy, another needs to be tried. The activity may be made less complex so that understanding is possible. Thus, the teacher may go back to working with pupils in understanding or reviewing what a set of five is.

3. guiding pupils to perceive reasons for leaning that which is stated in the objective. Sometimes, a pupil says, "Do we have to learn this?" I would suggest here to explain to pupils why it is important to learn what a set of ten is. The teacher should not feel threatened in these situations, but realize too that here are opportunities to reflect one's thinking on objectives to be emphasized in the teaching of mathematics.

4. sequencing learning opportunities in the teaching of mathematics. It takes good sequence when teaching mathematics if

pupils are to be successful in learning. How can the teacher(s) properly sequence for each pupil in a class of twenty-five? I would say to do the best possible. If collaborative learning is used, there still will be those who learn more rapidly that others. In large group instruction, the top achievers will achieve more rapidly than the rest in the classroom. Even in individualized study, such as a pupil reading a library book on the history of mathematics, written for children, there will be times when the contents will be easier therein as compared to other places in the library book. Then too, the mathematics teacher does not have the "gauges" to measure precisely where a pupil is in achievement now as compared to a plumber fitting standardized parts together to join pipes.

Pupils individually are unique and different from each other. They also possess multiple intelligences such as in art, music, physical education, social studies, science, reading and the language arts, as well as in mathematics. Whatever the mathematics intelligence of the pupil is, he/she should have the best curriculum possible to become proficient in the third of the 3rs. With a variety of materials of instruction, the teacher should be able to reach many pupils to learn as much as possible. These materials include the use of textbooks, videotapes, films, filmstrips, workbooks, worksheets, software packages, CD ROMS, concrete realia and objects, dramatizations, drawings, and models, among others. Recommended materials of instruction tend to be neutral, neither good nor bad, and require a good mathematics teacher who is creative to assist pupils individually to learn as much as possible (Ediger, 1995).

Constructivism in Mathematics

A relatively new concept of teaching and evaluation involves constructivism. Constructivism, among other things, involves appraising pupils within a contextual situation, not by external procedures (Ediger, 1998).. External procedures involves standardized tests written by specialists far removed from the local classroom scene.

Then too, the standardized tests are administered once and sometimes twice a year. If administered once a year, these tests are a one shot approach in determining how well pupils are doing in mathematics, and other curriculum areas.

With constructivism, the mathematics teacher may appraise continuously as pupils are learning in mathematics. Whatever problems pupils reveal in achievement or lack thereof can be monitored by the mathematics teacher. Then too, assistance may be given right away to the pupil experiencing a difficulty in mathematics. The every day evaluation results that the lay public hears little or nothing about comes to light and is indicated with constructivism as a concept in teaching and learning, Constructivism is

1. pupil centered in that the focus is upon the individual learner in determining how well he/she is doing.
2. sequential in that the pupil is assisted when difficulties are faced at that specific moment.
3. continuous in observing pupil achievement, not a one shot approach in appraising learner progress.
4. contextual and relates to what has happened previously in the ongoing lesson and unit of study.
5. emphasizes that the mathematics teacher is available at the time of need.
6. personal in that the appraisal is valid for a given pupil.

With constructivism, if a pupil does not understand place value such as ones, tens, and hundreds, the teacher, at that specific time, may provide needed assistance. This situation is a motivator for each and every pupil in mathematics.

Conclusion

Pupils need to be motivated to achieve as optimally as possible. There are numerous psychologists in education who have excellent suggestions for motivating learners. Teachers and supervisors need to study and analyze diverse schools of thought in educational psychology to ascertain which procedures work best and with which children in mathematics. They need to do much reading and studying to notice which trends in motivation and teaching of pupils are in vogue. Pupils individually are different from each other and possess diverse learning styles. They also possess different intelligences, such as being able to work better individually or within a committee. Teachers and supervisors need to study pupils in the classroom and know under which conditions pupils achieve best in pertaining to the mathematics curriculum.

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